

Arroyo Colorado: A Compilation and Evaluation of Prior Studies and Data

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This report was compiled per the project, “Arroyo Colorado Agricultural Nonpoint Source Assessment” funded by the TSSWCB through the CWA §319(h) NPS Grant Program. Under this project, TWRI was tasked to (1) compile historical water quality data and information from previous studies and conduct a detailed analysis of the most significant water quality parameters to investigate the trends and the different biological and physical process taking place in the watershed that contribute to changes in water quality in the Arroyo; (2) organize the results from the earlier non-point source pollution projects conducted in the Arroyo Colorado watershed and summarize the results and conclusions of these studies; and 3) identify critical data gaps that should be filled.

**Only water quality data related to agricultural or listed as unclassified was included.*

2/2/2012

Historical Water Quality Data

University of Texas – Pan American. 1995. Report of Literature Review on Discharges from the Rio Grande and Arroyo Colorado and their Impacts. Available online at: www.utpa.edu/csl/Acrobat/litrev.pdf

“Bryan (1971) reported on salinity, dissolved oxygen, pH, and temperature in the Arroyo Colorado from 1966 through 1969 (dates of initiation and ending not given). Hurricane Beulah (September 1967) occurred during the study, and rainfall resulting from the storm caused widespread flooding and many changes in the Arroyo. The water became more saline at all levels as it progressed downstream, and salinity increased with depth at all five stations (Bryan, 1971). During the study period, dissolved oxygen ranged from zero at the bottom (4.2 m) to 11 ppm at the surface (0.6 m). But in August 1967, surface dissolved oxygen values ranged from 1.4 to 3.4 ppm and the bottom contained no oxygen (Bryan, 1971). There was a significant inverse relationship between salinity and dissolved oxygen (Bryan, 1971). Bryan (1971) reported that eight fish kills occurred during his study in 1966-69 of the lower reach of the Arroyo Colorado. Most of these occurred between June and September. No direct sources of pollution were found in any of the cases, but in two kills that were investigated while in progress there was no oxygen at any level of the water column. The majority of fish found dead were menhaden, but other species were usually included.

White et al. (1983) found elevated levels of DDE and toxaphene in freshwater fishes at all sites where they occurred along the Arroyo, above the Port of Harlingen. Based on analysis of tissue samples obtained from the Arroyo Colorado in December 1987, Davis (1989) concluded that long-term human health risks may be associated with consumption of fish from the Arroyo Colorado due to elevated concentrations of chlordane, dieldrin, p, p' dde, and dacthal. In the Arroyo Colorado, toxic chemicals identified in screening as “of interest” included chlorine, ammonia, copper, nickel, selenium, zinc, methylene chloride, chloride, chlordane, dacthal, dieldrin, and p, p' dde. Potential sources of input were identified as urban runoff, municipal effluents, and agricultural runoff and return flows.”

Texas State Soil and Water Conservation Board. 1998. Arroyo Colorado Watershed Nonpoint Source Pollution Project Final Report: TSSWCB, CWA § 319(h) NPS Grant Project. Available online at: arroyocolorado.org

“Agricultural applications of pesticides and fertilizers, in conjunction with the irrigation and drainage systems of the area, have been implicated by various studies as contributing to water quality problems. Urban runoff and effluent from 26 wastewater treatment facilities in Segment 2202 and 6 facilities in Segment 2201 have also been cited as contributing to lower water quality in the Arroyo Colorado. The tidal segment experiences the expected saltwater intrusion and concomitant lower dissolved oxygen and higher salt content (Twidwell, 1978).

Data collected from Segment 2201 by the Texas Department of Water Resources (now the TCEQ) in 1976 indicated eutrophic conditions and the presence of pesticides in sediments (Twidwell, 1978). In 1980, the Texas Department of Health issued an advisory recommending restricted consumption of all fish from the Arroyo Colorado above Port Harlingen. Intensive surveys of Segment 2201, conducted by the Texas Department of Water Resources in the early to mid 1980s, consistently found evidence of eutrophication and pesticides. National Oceanic and Atmospheric Administration has reported that the Lower Laguna Madre watershed, which consists primarily of the Arroyo Colorado watershed, has the most intensively applied herbicides and insecticides of any watershed in Texas (TNRCC, 1994a). In addition, soil loss from cropland in the Lower Laguna Madre watershed exceeds that of the U.S. side of the Rio Grande Watershed, a decidedly larger area (TNRCC, 1994a).

Human activities frequently increase the amount of accumulated rainfall remaining on the land for extended periods. Standing water can cause a subsequent rise in the water table which ultimately increases soil salinity,

leading to non-productive soils. (USACE, 1990a)

TAEX (now the Texas AgriLife Extension Service), as part of this project, has **assembled a database of available water quality data on the Arroyo Colorado** (Fipps, 1996). The **database, available at <http://arroyo.tamu.edu/database.html>, contains data from 48 stations for the period of record from 1982 through 1994.**”

Texas Commission on Environmental Quality. TCEQ Pollutant Loading and Dissolved Oxygen Dynamics in the Tidal Segment of the Arroyo Colorado. July 2003

“Another study conducted in 1989 by the National Oceanic and Atmospheric Administration (NOAA) identified the Lower Laguna Madre as being at the highest level of risk, or susceptibility, for eutrophication among all other bays and estuaries in the Gulf of Mexico (NOAA, 1992). The high inflow of nutrients from the mainland was cited as a potential cause. The report states that the Lower Rio Grande Valley watershed (which ends at the southwest boundary of the Lower Laguna Madre) is one of the most intensely farmed watersheds in Texas, with approximately 28% of the land area classified as cropland and approximately 72% of available cropland in active cultivation.”

“The impact of irrigation return flows on overall water quality in the Arroyo Colorado was qualitatively determined to be significant.” (TWC, 1992)

“potential ammonia toxicity problems would be reduced by several mechanisms including conservative use of agricultural chemicals” (Black & Veatch, 1981)

“surveys showed elevated levels of ammonia nitrogen and chlorophyll *a* throughout the entire tidal segment” (TWC, 1994, 1995, 1996)

“Land use and land cover in the Arroyo Colorado watershed are composed of a complex mixture of agricultural, urban, and natural land which contributes large quantities of nutrients and BOD in the form of dissolved and particulate loadings during rainfall-runoff events and also as a result of irrigation return flows which occur mainly under low in-stream flow conditions.” (TCEQ, 2003)

Results of Prior Studies

Texas State Soil and Water Conservation Board. 1998. Arroyo Colorado Watershed Nonpoint Source Pollution Project Final Report

“Corps engineers analyzed a full array of plans to provide flood damage reduction for the urban watersheds and agricultural watersheds, but determined that Federal participation would not be economically justified at that time (USACE, 1990a). The study found that:

...pesticide contamination has been identified as a widespread problem of inland waters of the project area. The quality is also influenced by sewage effluent, cannery and food processing wastes, canal seepage and storm run-off. Increased runoff associated with any flood control or drainage project has the potential to increase these problems if proper planning efforts are not accomplished. Proper drainage design of agricultural land and implementation of various farming practices could significantly improve water quality of the area (USACE, 1990a).

The Corps recommends water conservation techniques and farming practices which could reduce the level of pesticides and improve water quality.

An analysis of long-term trends for seven water quality indicators including dissolved oxygen, sulfate, nitrate, fecal coliform, dissolved phosphorus, total phosphorus, and chloride was conducted for the North Floodway (Segment 2200), Arroyo Colorado, tidal (Segment 2201) and Arroyo Colorado, above tidal (Segment 2202). Results indicated that nitrate, dissolved phosphorus, total phosphorus and sulfate were potential water quality problems in all three of the designated segments (Fipps, 1996)."

Simulation of Flow and Water Quality of the Arroyo Colorado, Texas, 1989–99. By Timothy H. Raines and Roger M. Miranda U.S. GEOLOGICAL SURVEY; Water-Resources Investigations Report 02–4110.

"The model was used to simulate total point and nonpoint-source loads for selected water-quality properties and constituents for 1989–99 for urban, natural, and agricultural land-use types. **About one-third to one-half of the BOD and nutrient loads are from urban point and nonpoint sources, although only 13 percent of the total land use in the basin is urban.**"

Arroyo Colorado Watershed Protection Plan: Phase I. 2007. Available online at: arroyocolorado.org.

"As required by federal law, the Texas Commission on Environmental Quality (TCEQ) established TMDLs for four legacy pesticides in 2001 and added eight additional TMDLs for toxic organic compounds in 2003. In addition to these TMDLs, the TCEQ also completed a TMDL study to address low dissolved oxygen (DO) in 2002. The TMDL study showed that **extensive physical modifications (i.e. dredging and channelization for navigational purposes) and excessive nutrient concentrations were the cause of periodic, but occasionally severe, oxygen depletion in the boundary between the fresh water and tidally influenced portions of the stream.**"

Rosenthal, Wes. 1999. Final Report For the WQMP Implementation Assistance In the Arroyo Colorado Watershed Management, TSSWCB, CWA, §319(h) NPS Grant Project. Blackland Research Center. Available online at: arroyocolorado.org.

"From 1999-2000 and in 2001-2002, the TSSWCB obtained information on individual farmers/ranchers that implemented nutrient, irrigation, and residue management BMP's within the watershed.....**SWAT simulation results indicate both conventional and conservation tillage practices are not expected to degrade the ambient water quality on average** below EPA drinking water quality for nitrate-N levels. Both conventional and conservation tillage and nutrient management resulted in less than 5 ppm of nitrate-N concentrations. Total P concentrations were even less, below 0.8 ppm....Low nutrient losses were probably attributed to the fact that this watershed area has a very flat topography, which minimizes runoff and sediment losses....Major (SWAT) model output components include surface runoff percolation, groundwater contribution to stream flow, and sediment, pesticide and nutrient loadings."

Arroyo Colorado Agricultural Nonpoint Source Assessment. TSSWCB CWA §319(h) NPS Grant Project 06-10.

Updated land use/land cover data; database and map showing location and types of conservation practices implemented since 1995; monitoring of drainage ditches; evaluation of BMP effectiveness on reducing agricultural NPS loadings.

SWAT Model Simulation of the Arroyo Colorado Watershed. TSSWCB CWA §319(h) NPS Grant Project 07-09.

GIS maps related to soil, land use, and topography of the watershed; compile water quality data for 1999-2006; time series of average daily flow (in CMS) and sediment, BOD, NH₃-N, NO₂+NO₃, TN, OP and TP loadings (in metric units of mass) at the Port of Harlingen and for each sub-basin (10-14) downstream of the Port of Harlingen (flow to be reported as flow volume for the sub-basins) formatted for input into EFDC; and predictions based on model's results.

Data Gaps

Texas State Soil and Water Conservation Board. 1998. Arroyo Colorado Watershed Nonpoint Source Pollution Project Final Report. TSSWCB, CWA § 319(h) NPS Grant Project. Available online at: arroyocolorado.org

“We were not able to do statistical tests and trend analysis of the monitoring data due to the limited amount and inconsistency of the data, and experimental errors in the establishments of the sites.”

Rosenthal, Wes. 1999. Final Report For the WQMP Implementation Assistance In the Arroyo Colorado Watershed Management Project, TSSWCB, CWA §319(h) NPS Grant Project. Blackland Research Center. Available online at: arroyocolorado.org.

“This study is limited by the scarcity of validation data (crop yields and in-stream monitoring) for sedimentation and in-stream flow measurements of runoff (Rosenthal 1999). Additionally, the low N and P losses may be due to the fact that simulations were based on the simplified land use/cover conditions, i.e., all urban land was treated as unfertilized Bermuda grass. In the event that such simplifications were removed, using the actual urban land will probably simulate higher magnitudes of N and P losses.”

Arroyo Colorado Watershed Protection Plan: Phase I. 2007. Available online at: arroyocolorado.org.

“Uncertainty (of watershed loading estimates) associated with the DO TMDL analysis by TCEQ in 2002... Characterization of watershed loadings, in-stream rates and constants, and DO dynamics in the Arroyo Colorado should be improved to enhance understanding of the cause-and-effect relationships between flow, loadings, biochemical interactions and physical setting. Studies should include edge-of-field measurements of flow and constituent concentrations resulting from runoff and irrigation events, measurements of irrigation return flow volumes, direct monitoring of nutrient loading from municipal wastewater facilities, measurements of BOD in the upper portion of Segment 2201, measurements of nutrient cycling and algal productivity, measurements of particulate organic matter loadings from various sources in the watershed and measurement of the deposition and accumulation rates of particulate organic matter in the upper portion of Segment 2201. The results of the data collection efforts described above would be used to enhance the sophistication of modeling efforts and to refine the overall TMDL analysis of the Arroyo Colorado. More detailed hydrodynamic modeling should be conducted on the tidal segment of the Arroyo Colorado in order to better characterize the effects of the complex hydraulic environment that exists in Segment 2201. Additional data collection should be conducted to document kinetic rates, productivity parameters and nutrient cycling parameters for use in the hydrodynamic model.”

University of Texas – Pan American. 1995. Report of Literature Review on Discharges from the Rio Grande and Arroyo Colorado and their Impacts. Available online at: www.utpa.edu/csl/Acrobat/litrev.pdf

“Insufficient monitoring data are available to assess non-point-source pollution and toxic material loadings. A comprehensive study to identify and quantify the inputs for point and non-point sources and toxic materials loading should be initiated. Existing sampling programs should be expanded to provide for multi-depth quantification of nutrient concentration. Irrigation return flow, runoff and rainfall inputs are not monitored and there is no flow gauge near the mouth of the Arroyo Colorado to quantify discharge volumes to the lower Laguna Madre. Need to monitor shrimp farm effluent and runoff from shallow ponds.”

A CCD Camera-based Hyperspectral Imaging System for Stationary and Airborne Applications. Chenghai Yang a; James H. Everitt a; Michael R. Davis a; Chengye Mao

Hyperspectral Imaging System technology, an advanced technical capability applied on the Arroyo Colorado in a 2003 study shows potential for detecting point and non-point source pollution. Implementation into a management plan, however, is not feasible at this time due to high cost and continued refinement.

Texas Commission on Environmental Quality. TCEQ Pollutant Loading and Dissolved Oxygen Dynamics in the Tidal Segment of the Arroyo Colorado. July 2003

“Given the questions surrounding the appropriateness of the DO criteria currently applied to this (and other) tidal stream(s) located along the Texas Gulf Coast, a review of the applicability of the current DO criteria to the Arroyo Colorado should be conducted. The review should include updated biological information and water quality monitoring data. The review should also consider the altered physical nature of the water body and its relationship to use attainability.”

“Limited water quality data, other than DO, conductivity, and temperature exist below the mixed surface layer. This data limitation restricts the ability to calibrate and verify a model that vertically partitions the water body.”

“Background concentrations of constituents in soils, runoff, and irrigation return flows from sources such as atmospheric deposition and irrigation water are not well known. There is a potential error in loading estimates of constituents from these sources.”

“A quantitative, water quality target-based allocation of loadings is also problematic due to a general inability of the DO criteria applied to the Arroyo to take into account episodes of low dissolved oxygen that are the result of naturally occurring conditions”